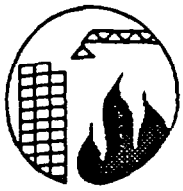


An Examination Of Variability and Precision For ASTM E648 Standard Test Method For Critical Radiant Flux Of Floor-Covering Systems

By

J. Randall Lawson

Product Safety Corporation. International Conference on Fire Safety, 18th. Volume 18. Proceedings. January 11-15, 1993, Millbrae, CA, Product Safety Corp., Sunnyvale, CA, 198-224 pp, 1993.

Research Work Was Sponsored In Part

by

The Carpet and Rug Institute
Dalton, Georgia

History: ASTM E648 / NFPA 253

- The first apparatus was built at Armstrong Cork Company by Zabawsky, in 1966.

- First use was a flame spread index compared to Red Oak.

- A cooperative program developed between Armstrong Cork and NBS, in 1972.

History continued:

- Corridor studies, by Denyes and Quintiere, showed the importance of measuring Critical Radiant Flux.

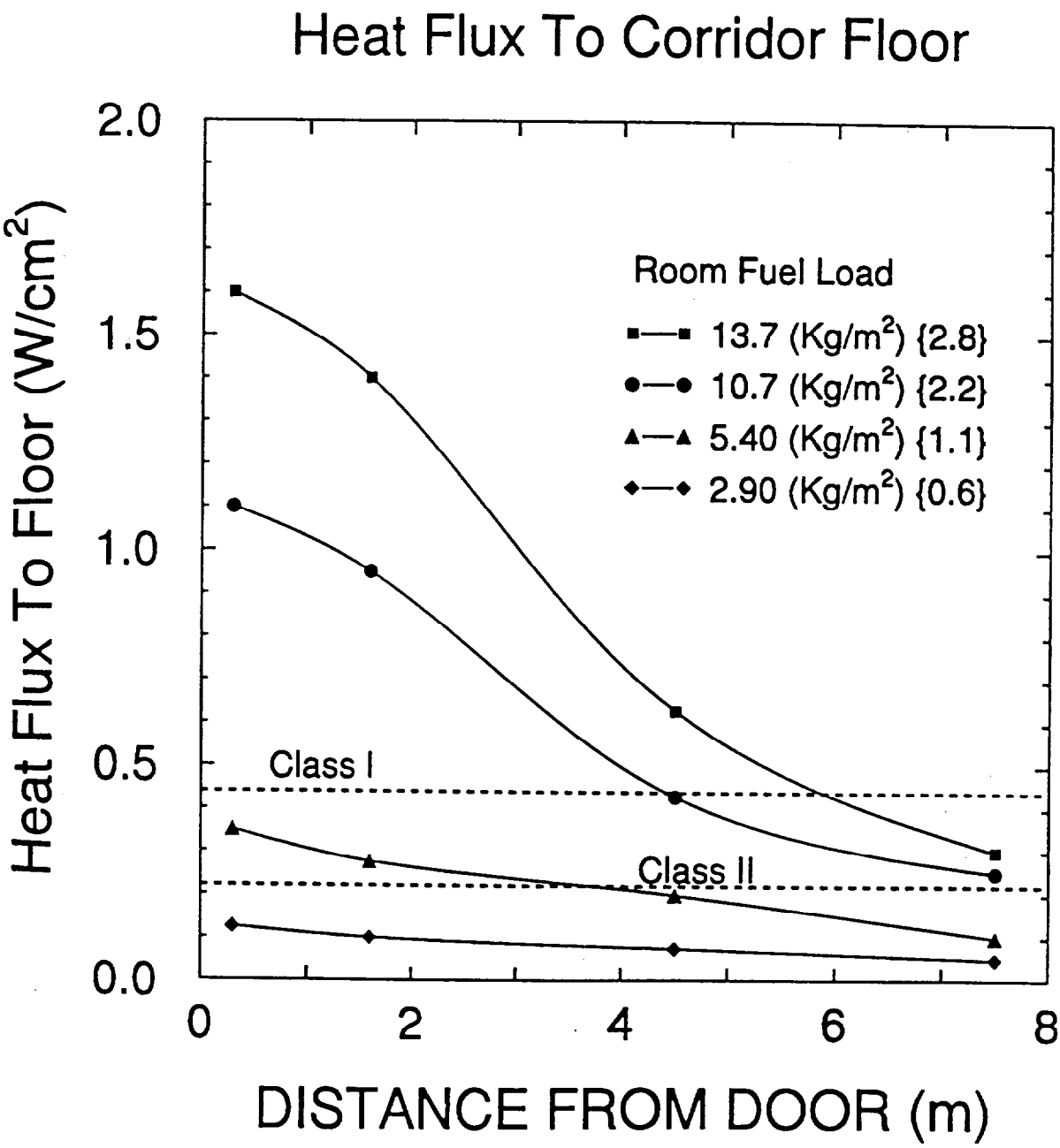
- L.G. Hartzell followed through on test procedure development at NBS as a Research Associate from Armstrong.

- The Flooring Radiant Panel was adopted by ASTM and NFPA as a standard, in 1978.

Test Theory:

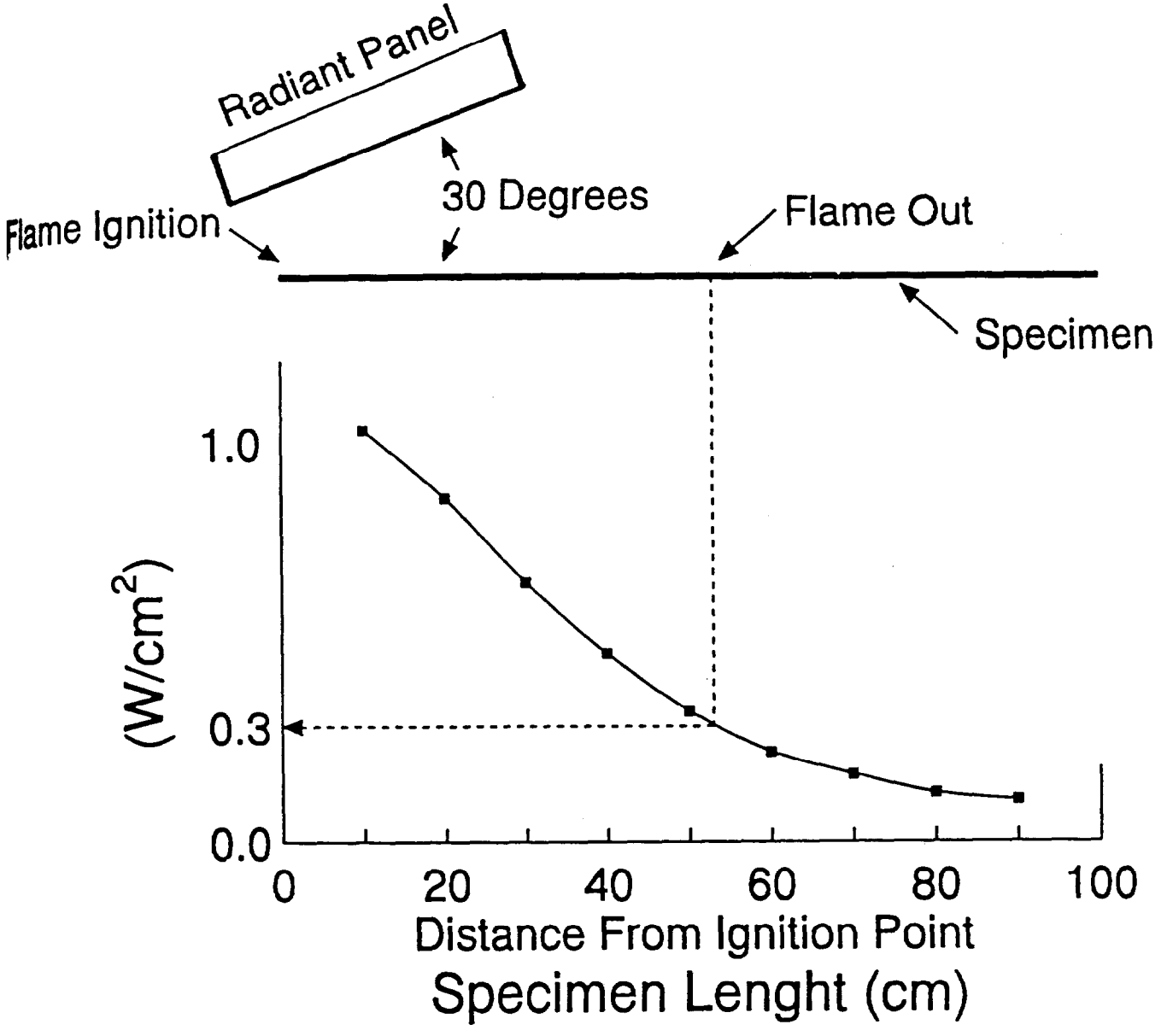
- Critical Radiant Flux - the level of incident radiant heat energy on a materials surface at the most distant point of self flame-out.

- Critical Radiant Flux is reported in units of - radiant heat energy / area.


Heat Flux To Corridor Floor
Heat Flux To Floor (W/cm²)
2.0
1.5
1.0
0.5
0.0
Room Fuel Load
13.7 (Kg/m²) {2.8}
10.7 (Kg/m²) {2.2}
5.40 (Kg/m²) {1.1}
2.90 (Kg/m²) {0.6}
Class I
Class II
0
2
4
6
8
DISTANCE FROM DOOR (m)

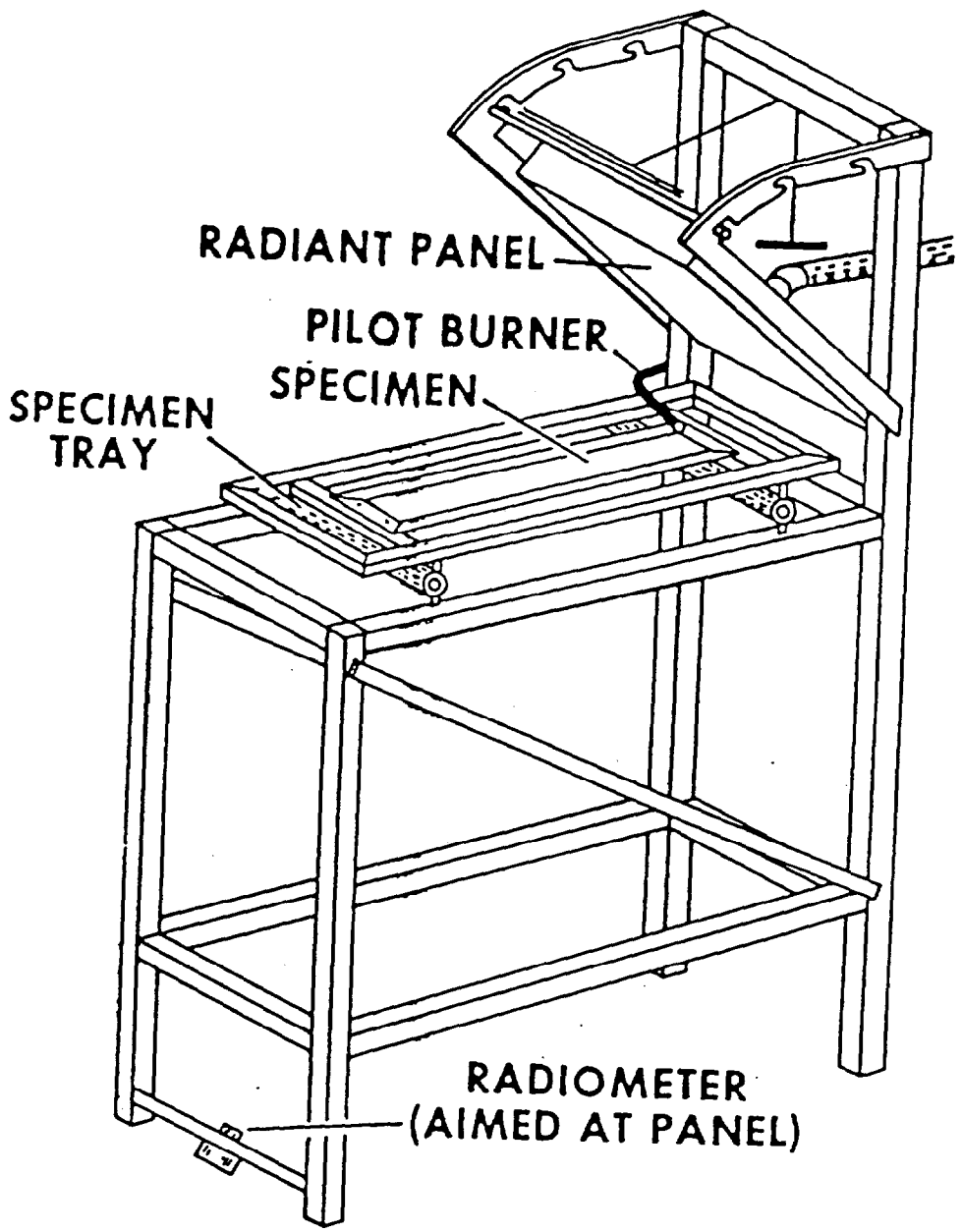
PRINCIPAL RADIANT PANEL ELEMENTS

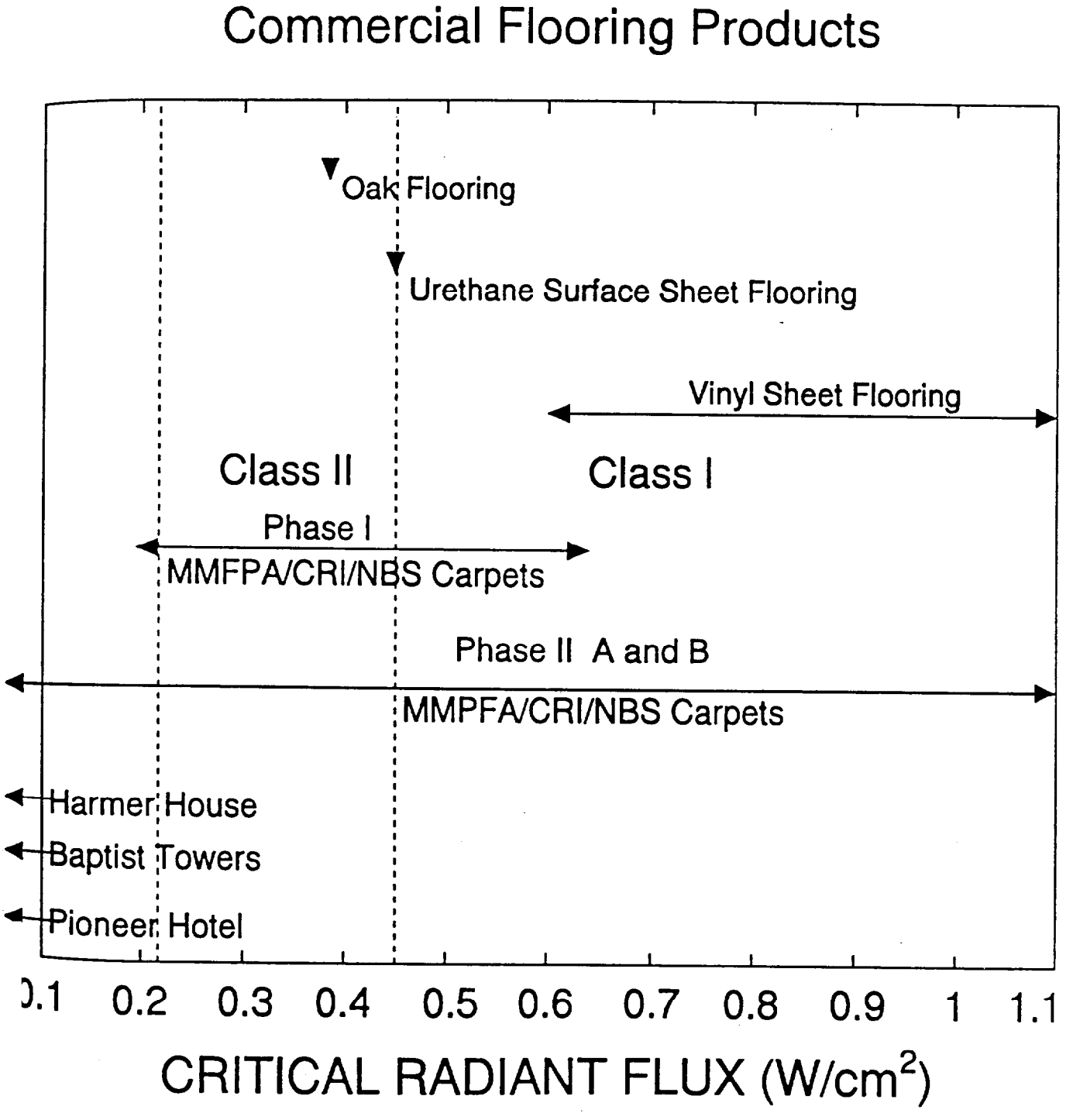
CRF Measurement Example



Radiant Heat Flux Curve

ORIGINAL APPARATUS




Commercial Flooring Products
Oak Flooring
Urethane Surface Sheet Flooring
Vinyl Sheet Flooring
Class II
Class I
Phase I
MMFPA/CRI/NBS Carpets
Phase II A and B
MMPFA/CRI/NBS Carpets
Harmer House
Baptist Towers
Pioneer Hotel
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
CRITICAL RADIANT FLUX (W/cm2)

MEASURES OF VARIABILITY

Year	Within Lab Repeatability (%)	Between Labs Reproducibility (%)
1975 10M/14L NBS/MMFPA CRI	20	35
1987 6M/11L/6R/3Y NVLAP	20	32 - 40

1987
CRI INTERLABORATORY STUDY

SINGLE CARPET, MULTI-LABORATORY TEST PROGRAM

TEST PROGRAM WAS STOPPED

CAUSE - VARIABILITY IN CARPET SPECIMEN IGNITION

MANY SPECIMENS WOULD NOT PROPAGATE FLAMES AWAY FROM THE IGNITION POINT.

RESULTS FROM 1987 CRI STUDY

48 TESTS WERE CONDUCTED

STATISTICS:

RANGE - 0.46 to >1.1 (W/cm^2)

20 Values were 1.1 or >1.1

FOR VALUES - <1.1:

Mean - 0.69 (W/cm^2)

COV - 24 %

ANALYSIS OF 1987 CRI INTERLAB TEST SPECIMENS

Studies showed that all test specimens ignited.

Generally, little flame propagation was noted which moved away from the ignition point.

Many carpet specimens did propagate flames as much a 40 cm away from the ignition point.

Pilot contact area generally occurred on one-half of the specimen's leading edge.

ADDITIONAL TESTS OF 1987 TEST SPECIMENS NIST AND PARTICIPATING LABORATORIES 1988

COMPARISON OF REUSLTS:

Year Number of Tests	Range (W/cm^2)	Values 1.1 or > (W/cm^2)	Mean <1.1 (W/cm^2)	CoV (%)
1987				
48	0.46 - >1.1	20	0.69	24
1988				
51	0.33 - >1.1	1	0.44	21
		Difference	0.25	

QUESTION: DOES THIS CARPET AGE RAPIDLY?

TEST VARIABILITY ISSUES IDENTIFIED FOR CRI/NIST STUDY 1989

Specimen Ignition ★

Adhesive / Gluing of Carpet ★

Radiant Panel Gas Type

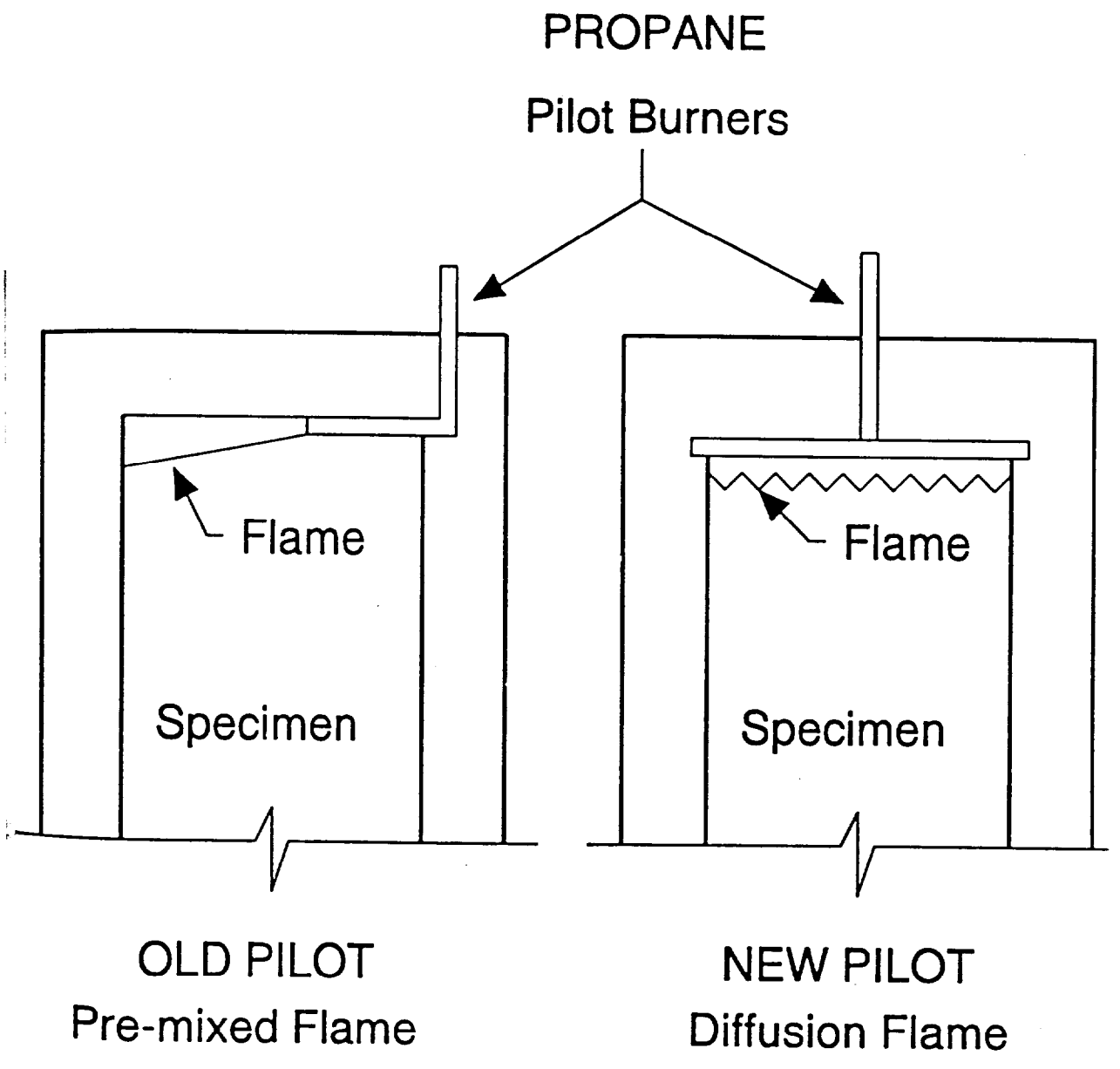
Specimen Preparation & Conditioning ★

10% Difference in Panel Radiant Flux

Specimen Preheat Time ★

Chamber Temperature and Air Flow ★

Specimen Orientation


PROPANE
Pilot Burners
Flame
Specimen
Flame
Specimen
OLD PILOT
Pre-mixed Flame
NEW PILOT
Diffusion Flame

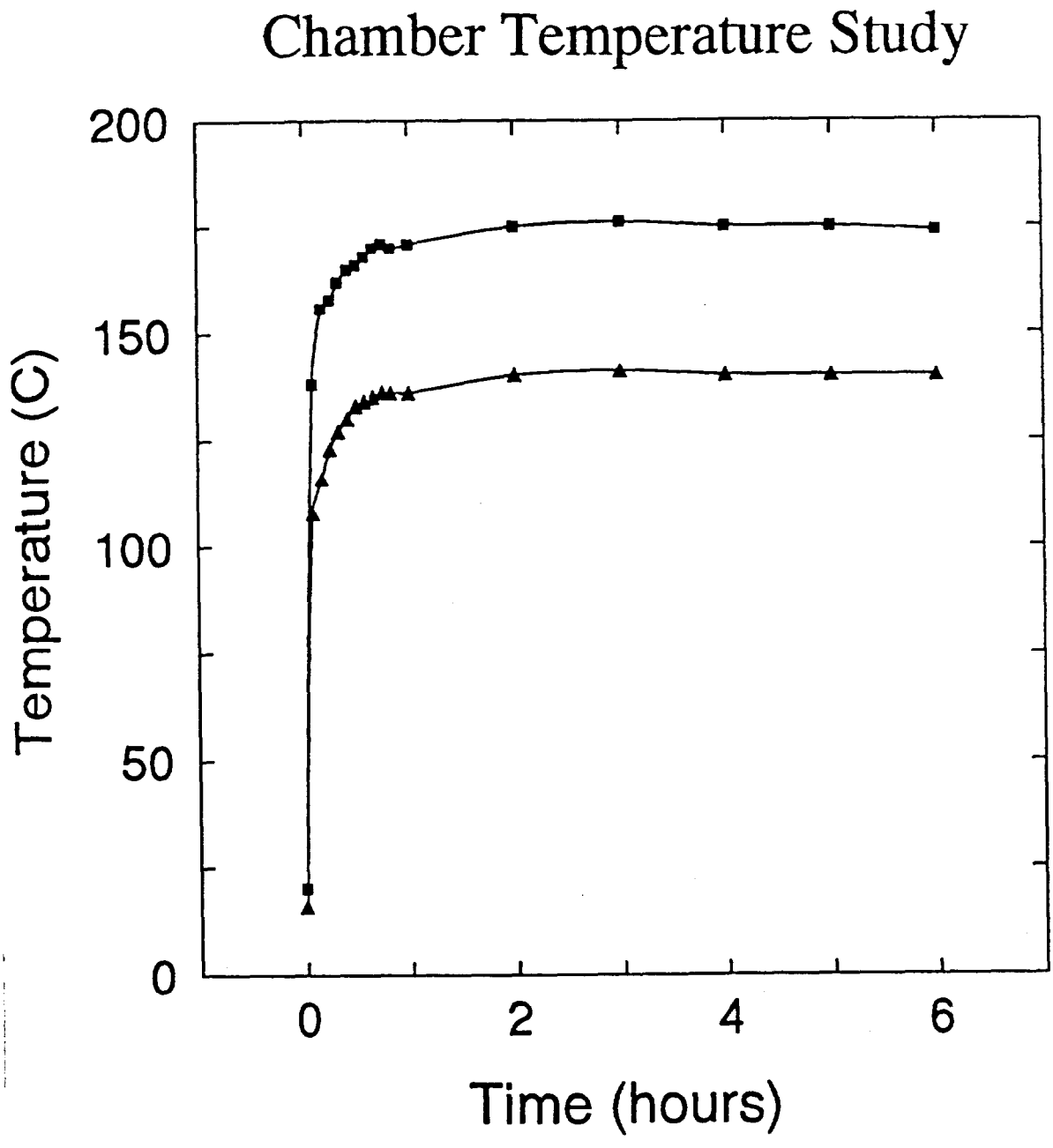
COMPARISON OF PILOT BURNERS OLD VS. NEW PILOT

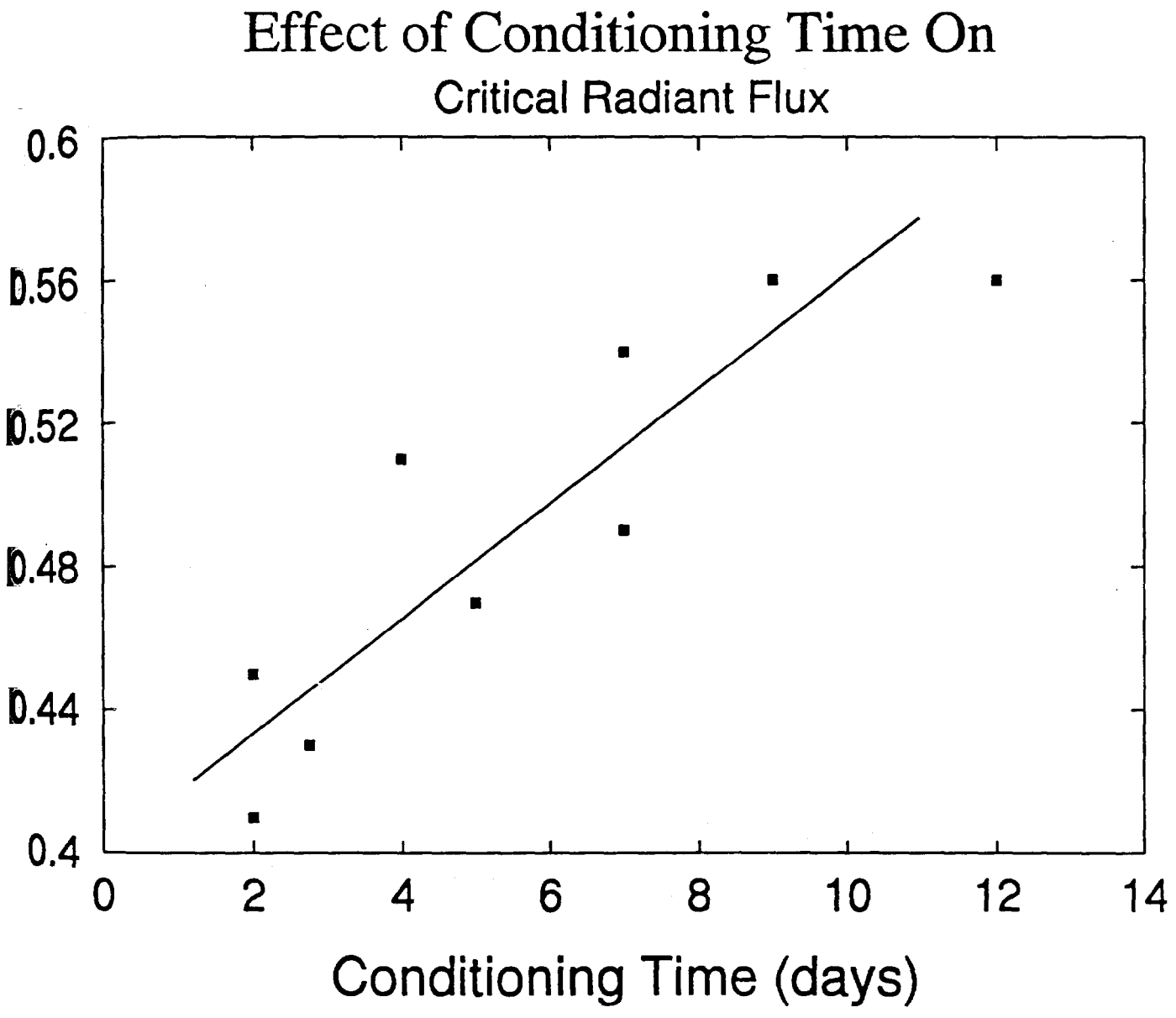
Tests done with carpet cut from the same roll.

Burner Type	Labs/ Replicates	Mean (W/cm^2)	s (W/cm^2)	CoV (%)
OLD	1/6	0.49	0.06	11.8
NEW	10/3	0.50	0.06	11.5

AIR FLOW
VS.
CRITICAL RADIANT FLUX

Chamber Stack Flow m/s (fpm)	Specimen Surface Flow m/s (fpm)	Average CRF (W/cm^2)
0.76 (150)	0.01 (19)	0.51 ±0.03
1.25 (250)	0.14 (27)	0.44 ±0.04
3.00 (600)	0.20 (39)	0.36 ±0.01


Chamber Temperature Study
200
150
100
50
0
Temperature (C)
0
2
4
6
Time (hours)
Lab A - Ambient Temperature Natural Gas Test
Lab B - Low Temperature Propane Test


Effect of Conditioning Time On
Critical Radiant Flux
0.6
0.56
0.52
0.48
0.44
0.4
0
2
4
6
8
10
12
14
Conditioning Time (days)

1992 CRI/NIST INTERLABORATORY STUDY

NEW ASTM E648 TEST PROCEDURE:

New Line Pilot Burner

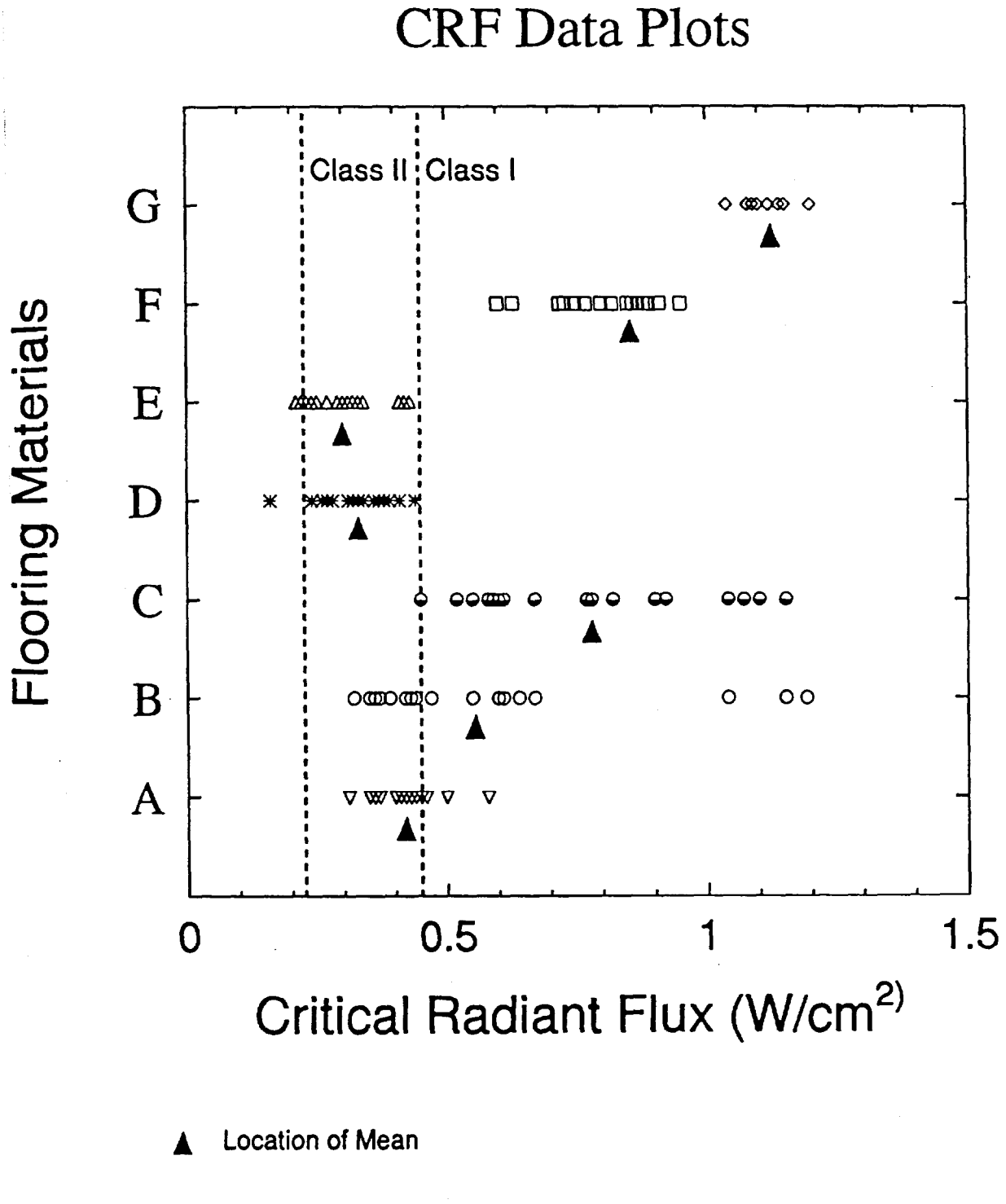
Five Minute Preheat

Increased Control Over Air Flow

More Specific Specimen Preparation Instructions

Interlab protocol conditioning limits:

No less than 4 days and not more than 10 days.


CRF Data Plots
Class II
Class I
G
F
E
D
C
B
A
Flooring Materials
0
0.5
1
1.5
Critical Radiant Flux (W/cm2)
▲ Location of Mean

MEASURES OF VARIABILITY

Year	Within Lab Repeatability (%)	Between Labs Reproducibility (%)
1975 10M/14L NBS/MMFPA CRI	20	35
1987 6M/11L/6R/3Y NVLAP	20	32 - 40
NEW TEST METHOD:		
1989 1M/10L CRI/NIST	1 - 14	11
1992 5M/7L 2M/7L CRI/NIST	2 - 20 26 & 36	4 - 25 32 & 50
1992 1M/11L NVLAP	11	12

INTERLABORATORY STUDY CONCLUSIONS

The Flooring Radiant Panel Test provides acceptable precision.

One type of carpet will shrink away from the pilot burner upon being heated. Means should be included to insure that the carpet can be ignited.

The standard should include more specific time limits on specimen conditioning times.

A means should be developed for testing and reporting highly variable flooring products.

FLOORING MATERIALS ISSUES

Data indicates that a particular type of carpet may rapidly age, changing from a strong Class I product to a Class II product in a matter of months.

HOW DOES THIS INFLUENCE FIRE SAFETY?

Certain flooring products exhibit high variability in test results, sometimes within a laboratory and between laboratories.

DUE TO THIS EXTREME VARIABILITY, HOW SHOULD THESE PRODUCTS BE REPORTED AND CLASSIFIED?

REGULATING AUTHORITIES

Does the rating CLASS I and CLASS II really provide different levels of fire safety?

How do the ratings, CLASS I and CLASS II, relate to the higher fuel loads found in buildings today?

How should regulators manage questions associated with highly variable products which may possess a mean test value just slightly above some magic number?

References:

Benjamin, Irwin A. and Adams, Howard C., The Flooring Radiant Panel Test And Proposed Criteria, NFPA Fire Journal, March 1976.

Davis, Sanford; Lawson, J. Randall and Parker, William J., NISTIR 89-4191, Examination of The Variability of The ASTM E648 Standard With Respect to Carpets, National Institute of Standards and Technology, 1989.

Lawson, J. Randall, An Evaluation of Precision for the ASTM E648-91A Standard Test Method for Critical Radiant Flux of Floor-Coverings Systems, National Institute of Standards and Technology, 1992